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An eel manager's toolbox for the southern Gulf of St. Lawrence

Une boîte à outils pour les gestionnaires des stocks d'anguille dans le sud du golfe du Saint Laurent

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ABSTRACT

Managers who wish to reduce commercial harvests of American eel by a particular amount need to know the relation between rule changes and projected harvest levels. Licence buy-backs could potentially reduce fishing harvest, but a large number of licences would have to be purchased before effort is reduced because of the large number of currently inactive licences. In New Brunswick (Gulf of St. Lawrence sector), shortening the fyke net fishing season would have the greatest effect on harvest if the reduction comes in fall. In Prince Edward Island, effects on harvest would be similar regardless of when during the two month season (mid-August to mid-October) a season reduction was imposed. Effects of increases in minimum legal size on harvest can be estimated from size structure data. For example, the imposition of a 55 cm minimum size is predicted to reduce harvest by 28% in Gulf New Brunswick and by 16% in Prince Edward Island. Increasing minimum distance between fixed gears would likely reduce harvests in areas where gear is currently set in high density, but quantitative predictions are not possible. Reductions of the number of gears per licence could reduce harvest, but effects would depend on rules governing transfer of gear authorizations between fishers. Imposition of a berth system for fixed gear would prevent the artificial increase in effort that comes when fishers place gear for the purpose of thwarting other fishers from taking the site. However, the extent to which such behaviour occurs is unknown. Eels are also subject to recreational spear fisheries in the southern Gulf, whose harvests could be restricted by changes in season, minimum size, or daily bag limits. Reliability of quantitative predictions of harvest reductions are constrained by changes in size structure that arise from fisheries and other causes, from natural population fluctuations, from limitations in the quality of data, and from behaviour of fishers. This paper provides an interim assist to managers who seek short-term predictions of management measures, pending the development of more robust predictive models.

RÉSUMÉ

Les gestionnaires qui veulent réduire les captures commerciales d'anguille américaine par une quantité donnée doivent connaître la relation qui existe entre les changements de règlements et les niveaux de captures projetés. Les rachats de permis de pêche pourraient potentiellement réduire les captures de pêche, mais un grand nombre de permis devrait être acheté avant que l'effort ne soit réduit en raison du grand nombre de licences actuellement inactives. Au Nouveau Brunswick (secteur du Golfe du Saint Laurent), réduire la durée de la saison de pêche au filet verveux aurait le plus grand effet sur les captures, si la réduction a lieu à l'automne. À l'île du Prince Édouard, les effets d'une réduction de la durée de la saison sur les captures seraient semblables peu importe quand sera imposée cette réduction pendant la saison de deux mois (la mi-août à la mi-octobre). Les effets d'une augmentation de la taille légale minimale de capture peuvent être évalués à partir des données de structure de taille. Par exemple, l'imposition d'une taille minimale de 55 cm permet de prévoir une réduction des captures de 28 % au Nouveau Brunswick et de 16 % à l'île du Prince Édouard. L'augmentation de la distance minimale entre des engins de pêche réduirait probablement des captures dans les secteurs où les engins de pêche sont actuellement en haute densité, mais des prédictions quantitatives ne sont pas possibles. Les réductions du nombre d'engin de pêche par détenteur de permis pourraient réduire les captures, mais les effets dépendraient de règlements régissant le transfert d'engin entre les pêcheurs. L'imposition d'un système de baux pour les engins de pêche fixes empêcherait l'augmentation artificielle de l'effort qui vient quand les pêcheurs placent un engin dans le but de contrecarrer d'autres pêcheurs désireux de prendre le site. Cependant, l'ampleur d'un tel comportement est inconnue. Les anguilles sont aussi soumises à la pêche récréative au harpon dans le sud du Golfe. Les captures de cette pêche pourraient être limitées par des changements de la saison, la taille minimale, ou des limites de captures quotidiennes. La fiabilité des prédictions quantitatives des réductions de captures est affectée par les changements de la structure de taille qui résultent de la pêche et d'autres causes, des fluctuations naturelles de population, des limitations dans la qualité des données et du comportement des pêcheurs. En attente du développement de modèles de prédiction plus robustes, ce document fournit une aide rapide aux gestionnaires qui cherchent des prédictions à court terme de la mise en place de mesures de gestion.

INTRODUCTION

Declines in American eel abundance indices in eastern North America have led to concerns about the sustainability of the resource (Haro et al. 2000, Richkus and Whalen 2000). A formal mechanism for assessing eel populations and recommending sustainable harvest levels is not yet in place for the American eel. However, the consensus among eel scientists is that there is an immediate need for conservation action, including the restraint or reduction of harvests (Anon. 2001a, 2003).

Eel fisheries are managed by a variety of rules, including those which govern season, minimum size, and inter-gear spacing. Eel managers who wish to bring about a reduction in harvest must choose which rule or rules to alter. To make such decisions, managers need to know the expected effect on harvest of a given change in fishing rules. The set of measures available to managers can be termed the manager's toolbox. This paper reviews available measures in the eel manager's toolbox for the southern Gulf of St. Lawrence, and evaluates their expected effects on harvest levels.

The evaluations presented in this paper are subject to important limitations. In some cases, weakness or absence of biological and fisheries data preclude quantitative analysis and predictions. Impacts on harvest from changing fishing rules are predicted under the assumption that size and age structure are constant. However, when fishing mortality is reduced due to more restrictive fishing rules, mean size and age in a population typically increase (Francis and Jellyman 1999). Hence the predictions in this paper apply most reliably to the beginning of the period in which the new rules are imposed, before the change in fishing rules alters population structure. The predictions become progressively less reliable in subsequent years, as the changes in the fishing regime bring about changes in population structure. It also must be borne in mind that fish populations change due to factors other than fisheries, and that such fluctuations will reduce the reliability of predictions.

Given these caveats, this paper can be seen as an interim assist to managers who want approximate predictions of short term effects of changes in fishing rules. In the long term, more reliable predictions of changes in fishing rules on harvest require population models that are based on better field data, and that incorporate feed-back between fishing rules and population structure.

MAIN FEATURES OF THE EEL FISHERY IN GULF REGION

Eel fisheries in Prince Edward Island and the Gulf of St. Lawrence drainages of New Brunswick and Nova Scotia are managed by Gulf Region of Fisheries and Oceans Canada. Eel management regimes in Gulf Region differ among the Region's three Areas (Gulf N.B., Gulf N.S., and P.E.I.). Regulations for these

Areas are summarized in Table 1. Integrated Fishery Management Plans (Anon. 2000, 2001b, 2001c) describe fisheries in these Areas.

The principal method for fishing eels in all three Areas is the fyke net (also referred to as eel traps, eel nets, eel trapnets, and hoopnets). Commercial spearing licences are issued in Gulf N.S. and on P.E.I., but this fishery has limited activity in Gulf N.S. and no activity in P.E.I. due to limited market demand for speared eels. There is a recreational spear fishery for eels in each Area, which does not require a licence.

Telephone surveys conducted in Gulf N.S. in 2001 revealed little fishing activity (Table 2). Only 4.7% of fyke net licence holders reported fishing eels with this gear. In P.E.I., phone surveys to fyke net licence-holders in 2000 indicated an activity level of 29.6%. No data on activity levels are available for Gulf N.B., but anecdotal reports suggest that the majority of licences are inactive.

TOOLS IN THE MANAGER'S TOOLBOX

Licence buy-backs

Buying back fishing licences is a potential means of reducing fish harvest. However, harvest is not reduced if the licence that is bought back is currently unused. Under current rules, eligible fishers may obtain licences by transfer from other fishers. If a currently used licence is bought back, but the fisher obtains another licence by transfer from another fisher whose licence is inactive, there will be no reduction in fishing effort.

Let us assume for the moment that all unused licences would have to be bought back before there is a reduction in fishing effort, and that activity levels estimated in phone-out surveys in 2000 and 2001 are currently valid. If this so, then about 95% of fyke net licences in Gulf N.S. and about 70% of fyke net licences in P.E.I. would have to be bought back before effort would be reduced in these fisheries.

Changes in fishing season

Reduction in fishing season is a potential means to reduce harvest. Table 3 and Fig. 1 show reported landings for 1998-2002 for the Gulf N.B. and P.E.I. fyke net fisheries, by half-month (Data from DFO Statistics Branch). In Gulf N.B., where the season is open from 1 April to 31 October (Table 1), landings per half-month increased in spring, dipped in June, and then peaked in September (Fig. 1). In P.E.I., where the season runs from mid-August to mid-October, landings per half-month were virtually constant.

Table 4 and Fig. 2 present reported landings from the Gulf N.B. spear fishery, the Gulf N.S. fyke net fishery, the Gulf N.S. spear fishery, and the P.E.I. spear fishery, by month. The majority of reported landings in these fisheries are estimated by

statistical officers, rather than summed from sales records. These landings are shown per month because estimates are filed on a monthly basis. Tables 3 and 4 give landings per month or half-month as a percent of landings by the gear in question, and as a percent of total landings for all gears.

In Gulf N.B., changes in fyke net fishing seasons that curtail fishing in the fall would lead to greater harvest reductions than curtailments of open season in the spring and summer. In Prince Edward Island, fyke harvest levels are virtually constant over the two month season (mid-August to mid-October), so the effects of a season shortening would be the same regardless of which time period was closed to fishing.

The percentages in Tables 3 and 4 can be used to make quantitative predictions of the decrease in landings that would ensue from a shortening of the fishing season. To illustrate, assume that the beginning of the fyke net season in Gulf N.B. shifts from 1 April to 1 June. Mean fyke net harvest during April and May, for 1998-2002, was 0.47+2.05+7.36+7.56=17.44% of total fyke net landings (Table 3). Thus, if fishing patterns remain constant, banning eel fyke netting in April and May in Gulf N.B. would reduce harvest by 17.44%. Similar analyses can be made using the percent harvest data in Table 4.

Size restrictions

The harvest of a fishery can be altered by setting or changing rules regarding the size of fish which can be retained. Most often, this is done by rules which establish minimum retention sizes. Assuming that all legal-sized fish are large enough to be retained by the gear (which is the case with gear used to catch eels in Gulf Region), the immediate effect of a change in minimum size on landings depends on the size structure of the population. Size structure of eels that are subject to regular commercial fisheries has been measured at two sites in Miramichi Bay and Estuary of Gulf N.B. (n=508), and in numerous locations on P.E.I. (n=2,678) (Fig. 3). For this analysis weights of the eels which were not weighed in the field were estimated from a length-weight relation calculated from 5,386 eels which were weighed and measured in the southern Gulf (weight = 0.0007825 length$^{3.205}$, where weight is in g and length is in cm; Cairns unpubl. data).

Table 5 indicates expected changes in landings given changes of minimum size from 2003 levels, to various minimums between 45 and 60 cm. This analysis is most reliable for P.E.I., where sample size for length frequencies of commercially fished populations is large. It is less reliable for Gulf N.B., where size data are available only for the Miramichi area.

To illustrate these predictions, let's say that minimum size is to increase to 55 cm in Gulf N.B. and in P.E.I. Landings (by weight) are predicted to decrease by 28% in Gulf N.B. and by 16% in P.E.I. (Table 5). Predicted landings reductions given a minimum size of 58 cm would be 44% in Gulf N.B. and 23% in P.E.I.

Gear spacing

Minimum spacing between fixed gears is 200 m in all Areas (Table 1). Increasing this spacing is a potential means to reduce harvest. There are no quantitative data on current spacing patterns of eel gear in the southern Gulf. Anecdotal reports indicate that in the Gulf shore of western P.E.I., fyke nets are commonly placed at the minimum legal spacing, so that there is no room for additional gear. In this situation, an increase in minimum spacing would lead to a decrease in the number of nets per watercourse. Density of eel gear in central and eastern P.E.I. is not as high as in western P.E.I. In these areas, an increase in minimum required spacing might reduce the number of gears in some, but not all, watercourses. In Gulf N.S., increases in minimum gear spacing would probably have little effect on number of nets per watercourse, because current fishing effort is so small.

Most eels harvested in Gulf Region are of the yellow phase. Yellow eels commonly move within restricted home ranges, with maximum movements less than 200 m in any direction (Helfman et al. 1983, Bozeman et al. 1985, Cairns unpubl. data). This suggests that a reduction of nets in a watercourse will likely reduce the encounter rate between eels and gear, and therefore reduce harvest. However, no experimental data are available to test the supposition that a reduction of the number of nets in a watercourse will reduce harvest levels.

In sum, increases in minimum gear spacing are likely to reduce harvest levels in areas where gear is currently set at high densities. However quantitative predictions are not possible due to lack of data.

Gears per licence

Eel licences set limits on the number of fixed gears that individual fishers can use. A reduction in the number of gears per licence would reduce fishing effort, and therefore landings. However, the percent reduction in harvest might be less than the percent reduction in gears per licence, because fishers would likely retain their best fishing sites, while abandoning the sites that fish less well. Effects of reductions on the number of gears per licence would depend on the rules governing transfer of gear authorizations between fishers, given that some licences authorize more gears than others.

Berth system

Anecdotal reports on P.E.I. indicate that some nets are installed on opening day only to hold the fishing site, and prevent other fishers from using it. This arises from competition among fyke net fishers for good fishing sites, especially where nets are placed at or near the minimum legal spacing. In such cases current fishing rules, which allow fishers to place nets in tidal waters anywhere in a broad geographical area, can be seen as leading to an artificial increase in fishing effort.

This problem could be avoided by the establishment of a berth system, in which fishing sites are reserved for specific fishers. Under such a system, a fisher could delay setting nets for several weeks after the opening of the season, without fear that his or her fishing sites would be taken by other fishers.

The extent to which eel fishing effort is artificially increased by the placement of nets to hold sites is not clear. Anecdotal reports indicate that many fishers fish all their gear from the opening day on, and that this pattern would not change if a berth system were imposed. In some areas of P.E.I., site placement is established by "gentlemen's agreement" among fishers, so fishers do not need to place nets to hold sites. Further discussions with or surveys of fishers would be required to determine if establishment of a berth system would lead to any substantial change in fishing effort.

Restrictions on recreational fisheries

Eel landings by recreational spear fisheries are poorly known because landings are estimated, not measured. Estimated recreational spear landings for 1998-2002 are 13.7% of total reported landings in Gulf N.B. and 9.8% of total reported landings in P.E.I. (Cairns unpubl. data). Harvest by recreational spearers could be reduced by shortening the season (see above), by increasing the minimum size, or by reducing the daily bag limit. Reducing the minimum size might not decrease fisheries mortality during winter spearing because fishers cannot see the eels they are spearing until they are brought up on the ice, and speared eels do not necessarily survive if released. Effects of reducing bag limits on landings cannot be evaluated because the frequency distribution of daily catches is not known.

DISCUSSION

The reliability of predictions of harvest reduction following change in fishing rules depends on the quality of the data used in analysis. Landings data for the Gulf N.B. and P.E.I. fyke net fisheries are derived from sales records and are reasonably reliable. Most landings data for other fisheries are based on estimates and are less reliable. Evaluations of the effects of minimum size changes on P.E.I. are based on measurements of a large number of eels at a variety of locations. These evaluations are probably fairly valid. Minimum size evaluations are less valid for Gulf N.B., where length data were obtained from the Miramichi area only. In some cases (e.g. inter-gear spacing, frequency distribution of daily recreational catch), no data are available, so no quantitative predictions are possible.

The analysis presented in this paper assumes that the introduction of new fishing rules will not lead to changes in fishers' behaviour, other than the changes imposed by the new rules. However, fishers are likely to react to changes in fishing rules in ways that minimize the effects of the changes. For example, a fisher faced with tightened fishing rules may abandon fishing in places where catch rate is below average, and concentrate fishing effort in places where catch rate has

been above average. This would mean that harvest reduction would be less than that predicted by the analyses in this paper.

Predictions of the effect of changing minimum size on harvest assume a constant age and size distribution. However, age and size distribution are influenced by fishing practices which may change with new fishing rules (Francis and Jellyman 1999). Age and size distribution also fluctuate due to factors other than the fishery. Predictions of the effects of changing minimum size on harvest are probably fairly reliable in the period immediately after the new rules are implemented, because the age and size structure will have changed little since the analysis was done. In subsequent years, there is a chance that age and size structure will change more, so the reliability of the predictions will gradually diminish.

A long-term objective of eel fisheries management is to allow a sufficient number of female silver eels to escape to the spawning ground, to produce the young that will replenish continental populations in future years (Anon. 2001a). A decrease in harvest, as recommended by Anon. (2001a) and Anon. (2003), is an interim measure which will move the eel fishery in the direction of sustainability. In the long-term, data and models that are beyond the scope of this paper are required to predict the changes of fishing rules on harvest, and to determine levels of fishing that are sustainable.

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Table 1
Summary of regulations governing commercial and recreational eel fisheries in the southern Gulf of St. Lawrence in 2004. There is no fishery for American eel elvers in the southern Gulf of St. Lawrence.

Region	Sector	Waters	Gear	Open season	Licence required	Minimum distance between gears (m)	Minimum size (cm) that may be retained	Comments
NB	Commercial	Tidal[a]	Fyke nets	1 Apr - 31 Oct	Yes	200	50.0	The open season in Tabusintac is 1 Aug - 31 Oct. The minimum size in all Gulf NB eel fisheries was increased from 20 cm to 38.1cm in 1996, from 38.1 cm to 46 cm in 2001, and from 46 cm to 50 cm in 2004.
	Commercial	Tidal	Longlines	1 Apr - 31 Oct	Yes		50.0	
	Recreational	Tidal	Spears	16 Nov - 31 Aug	No		50.0	A maximum of 10 eels per day may be retained.
NS	Commercial	Tidal[a]	Fyke nets	1 Sep - 31 Oct	Yes	200	50.0	The minimum size in all Gulf NS eel fisheries increased from 20 to 46 cm in 1996, and from 46 cm to 50 cm in 2001.
	Commercial	River	Weirs	1 Sep - 31 Oct	Yes	200	50.0	Used in non-tidal portions of the Margaree River to capture descending silver eels.
	Commercial	Tidal[a]	Pots	1 Sep - 31 Oct	Yes	200	50.0	
	Recreational	Tidal	Pots	1 Sep - 31 Oct	Yes	200	50.0	A maximum of 10 eels per day may be retained. Only 6 licences are issued.
	Commercial	Tidal	Spears	15 Jan - 30 Jun	Yes		50.0	
	Recreational	Tidal	Spears	15 Jan - 30 Jun	No		50.0	A maximum of 10 eels per day may be retained.
PEI	Commercial	Tidal	Fyke nets	16 Aug - 15 Oct	Yes	200	50.8	A 46 cm minimum size was imposed in all PEI eel fisheries in the 1970s. The limit was raised to 50.8 cm in 1998. In 1999, the open season for the trap-net fishery was changed from 16 Aug - 31 Oct to 16 Aug - 15 Oct.
	Commercial	Tidal	Spears	17 May - 30 Jun	Yes		50.8	Prior to 1993, the season was 1 Apr - 15 Aug. Prior to 1996, spearing was also permitted in Nov. In 1999, the season was changed from 1 Apr - 30 Jun to 17 May - 30 Jun. In 2001, the season was changed from 17 May - 30 Jun to 1 - 30 Jun. This fishery is currently inactive due to market conditions.
	Recreational	Tidal	Spears	1 Jan - 31 Mar	No		50.8	A maximum of 6 eels per day may be retained.

[a]Some gears are licenced for specified non-tidal waters

Table 2
Licenced effort in the commercial fishery for eels in the southern Gulf of St. Lawrence.

Area	Statistical districts[a]	Number of eel licences[b]	No. of licences authorizing fishing with[c]					Number of licenced gears[c]				Percent of licences which are active[d]					
			Fyke nets	Long-lines	Pots	Weirs	Spears	Fyke nets	Longline hooks	Pots	Weirs	Fyke nets	Long-lines	Pots	Weirs	Winter spears	Summer spears
Gulf New Brunswick																	
Bay of Chaleur	63-65	1	1	0	0	0	0	2	0	0	0	N/A	N/A				
Gulf North	66-68	42	42	1	0	0	0	976	100	0	0	N/A	N/A				
Miramichi	70-73	63	63	0	0	0	0	727	0	0	0	N/A	N/A				
Gulf Central	75-76	37	26	12	0	0	0	198	5,100	0	0	N/A	N/A				
Gulf Southeast	77-80	31	31	0	0	0	0	199	0	0	0	N/A	N/A				
Total		174	163	13	0	0	0	2,102	5,200	0	0	41.0	15[e]				
Gulf Nova Scotia																	
Cumberland/ Colchester	10, 45-46	22	7	0	20	0	1	18	0	568	0	0		0		0	0
Pictou	11-12	39	7	0	21	0	15	67	0	605	0	0		0		0	9
Antigonish	13	46	25	0	11	0	19	200	0	231	0	0		0		17	0
Cape Breton	2-3	30	9	0	11	16	0	52	0	225	18	29		0	25		
Total		137	48	0	63	16	35	337	0	1,629	18	5		0	25	10	3
Prince Edward Island																	
Prince	82, 83, 92, 93	582	137	0	0	0	523	2,693	0	0	0	31					N/A
Queens	85, 86, 95, 96	130	35	0	0	0	120	803	0	0	0	32					N/A
Kings	87, 88	82	66	0	0	0	36	1,321	0	0	0	25					N/A
Total		794	238	0	0	0	679	4,817	0	0	0	30					N/A

[a]Area where fishing is permitted, if location is specified in the licence; otherwise home address of the licencee. Most Gulf NS licences, and all Gulf NB licences, restrict fishing to specified areas. PEI licences do not restrict fishing to specified areas.

[b]Includes licences issued to aboriginal bands.

[c]From DFO licencing files for 2003.

[d]Gulf New Brunswick data for 2003, from analysis of purchase slips and commercial logbooks (G. Ferguson, DFO, Tracadie NB, pers. comm.). Gulf Nova Scotia and P.E.I. data from phone-out surveys in 2001 and 2000, respectively (Cairns et al. unpubl.). Blank cells indicate that data are unavailable. N/A means data unavailable.

[e]Value is either 2 of 13 (15%) or 3 of 13 (23%)

Table 3
Reported landings (tonnes) of American eels captured by fyke nets in Gulf New Brunswick and in Prince Edward Island, by half-month, 1998-2002

	Half month[a]																							
	January		February		March		April		May		June		July		August		September		October		November		December		Total
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	
New Brunswick fyke																									
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.66	1.31	2.15	2.32	2.07	2.96	5.72	5.39	6.32	9.00	4.22	3.13	0.02	0.01	0.00	0.00	45.62
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	2.53	1.94	1.71	2.17	2.39	4.66	3.07	5.22	2.43	6.65	2.91	0.98	0.05	0.00	0.00	0.00	37.64
2000	0.00	0.00	0.00	0.00	0.00	0.00	1.47	2.26	6.51	5.87	3.44	4.35	7.23	4.75	4.82	3.96	8.68	6.79	7.49	2.34	0.04	0.01	0.00	0.00	70.00
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.62	9.46	6.54	2.90	2.07	5.75	9.30	6.82	6.81	8.64	10.19	7.27	2.13	0.02	0.00	0.00	0.00	79.53
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.05	1.53	4.84	9.01	4.94	3.06	7.57	7.64	9.16	10.16	8.82	13.41	8.83	3.03	1.10	0.28	0.00	0.23	93.67
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.30	1.34	4.80	4.93	3.03	2.80	5.00	5.86	5.92	6.31	6.98	9.21	6.14	2.32	0.24	0.06	0.00	0.05	65.29
% of this gear	0.00	0.00	0.00	0.00	0.00	0.00	0.47	2.05	7.36	7.56	4.63	4.28	7.66	8.98	9.07	9.66	10.69	14.10	9.41	3.56	0.37	0.09	0.00	0.07	100.00
% of all gears	0.00	0.00	0.00	0.00	0.00	0.00	0.40	1.76	6.31	6.49	3.98	3.67	6.57	7.70	7.78	8.29	9.17	12.10	8.07	3.05	0.32	0.08	0.00	0.06	85.82
Prince Edward Island fyke																									
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.25	2.95	3.65	1.35	0.95	0.00	0.00	0.00	0.00	14.14
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.05	8.22	8.69	6.86	0.68	0.00	0.00	0.00	0.00	29.50
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.90	14.72	13.17	15.14	2.36	0.00	0.00	0.00	0.00	58.29
2001	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.95	8.25	9.60	7.84	0.52	0.00	0.00	0.00	0.00	39.16
2002	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.03	0.23	19.96	20.70	17.86	22.02	3.36	0.00	0.10	0.00	0.00	84.38
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.01	0.05	11.22	10.97	10.59	10.64	1.57	0.00	0.02	0.00	0.00	45.10
% of this gear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.01	0.10	24.88	24.32	23.49	23.60	3.49	0.00	0.04	0.00	0.00	100.00
% of all gears	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.01	0.09	22.44	21.94	21.19	21.28	3.15	0.00	0.04	0.00	0.00	90.19

[a]A means 1st to the 15th, B means 16th to the end of the month

Table 4
Reported landings (tonnes) of American eels captured by spear in Gulf New Brunswick, Nova Scotia, and Prince Edward Island, and by fyke net in Nova Scotia, by month, 1998-2002.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
New Brunswick spear													
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.29	1.27	0.00	0.00	2.56
1999	2.99	0.73	0.27	0.00	0.27	0.27	0.27	0.27	0.68	0.41	0.00	2.72	8.89
2000	1.13	1.13	0.23	0.68	0.36	0.57	0.43	0.27	0.32	0.32	0.45	0.45	6.35
2001	0.79	0.20	0.18	2.00	1.18	1.18	0.50	0.32	2.72	2.68	0.45	0.45	12.65
2002	0.11	0.11	0.00	1.13	1.72	3.08	2.74	0.11	2.49	2.38	3.99	3.88	21.77
Mean	1.01	0.43	0.14	0.76	0.71	1.02	0.79	0.20	1.50	1.41	0.98	1.50	10.45
% of this gear	9.64	4.16	1.30	7.30	6.77	9.77	7.56	1.87	14.37	13.51	9.38	14.37	100.00
% of all gears	1.32	0.57	0.18	1.00	0.93	1.34	1.04	0.26	1.97	1.85	1.29	1.97	13.73
Nova Scotia fyke													
1998	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.88	6.41	2.87	0.00	0.00	10.25
1999	0.00	0.00	0.00	0.00	0.09	0.07	0.00	0.46	3.04	3.73	0.00	0.00	7.39
2000	0.00	0.00	0.00	0.00	0.05	0.15	0.00	0.00	3.75	1.67	0.07	0.00	5.68
2001	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	1.66	1.16	0.00	0.00	2.95
2002	0.13	0.17	0.04	0.02	0.00	0.03	0.00	0.00	1.74	1.14	0.00	0.00	3.28
Mean	0.03	0.03	0.01	0.00	0.05	0.07	0.00	0.27	3.32	2.11	0.01	0.00	5.91
% of this gear	0.45	0.57	0.15	0.07	0.78	1.25	0.00	4.53	56.20	35.78	0.22	0.00	100.00
% of all gears	0.35	0.44	0.11	0.06	0.60	0.96	0.00	3.49	43.26	27.54	0.17	0.00	76.98
Nova Scotia spear													
1998	1.99	1.52	0.01	0.00	0.34	0.65	0.02	0.00	0.00	0.00	0.00	0.00	4.54
1999	0.83	0.41	0.04	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.62
2000	0.55	0.52	0.05	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20
2001	0.20	0.19	0.04	0.01	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46
2002	0.48	0.32	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90
Mean	0.81	0.59	0.05	0.09	0.07	0.13	0.00	0.00	0.00	0.00	0.00	0.00	1.74
% of this gear	46.29	33.85	2.96	4.99	4.15	7.50	0.26	0.00	0.00	0.00	0.00	0.00	100.00
% of all gears	10.52	7.69	0.67	1.13	0.94	1.71	0.06	0.00	0.00	0.00	0.00	0.00	22.73
Prince Edward Island spear													
1998	2.32	2.11	1.30	0.00	3.39	0.00	0.00	0.07	0.22	0.04	0.00	0.00	9.45
1999	2.28	2.07	1.23	0.00	0.00	0.00	0.00	0.00	0.17	0.06	0.00	0.00	5.80
2000	2.15	1.92	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.20
2001	0.53	0.86	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.03
2002	0.54	0.86	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.04
Mean	1.56	1.56	0.99	0.00	0.68	0.00	0.00	0.01	0.08	0.02	0.00	0.00	4.90
% of this gear	31.89	31.85	20.15	0.00	13.83	0.00	0.00	0.27	1.59	0.41	0.00	0.00	100.00
% of all gears	3.13	3.12	1.98	0.00	1.36	0.00	0.00	0.03	0.16	0.04	0.00	0.00	9.81

Table 5
Expected percent change in landings of American eels in comparison with 2003, by weight and by number of animals, at given minimum retention sizes. Expected changes are for the year in which the change in minimum size is introduced. Minimum sizes in effect in 2003 were 46 cm in Gulf New Brunswick and 50.8 cm in Prince Edward Island.

	Expected percent change in landings, at given minimum retention sizes (cm)																					
	45	46	47	48	49	50	50.8	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
Gulf New Brunswick																						
Percent change in weight	1.5	0.0	-1.3	-4.2	-5.5	-9.1	-10	-12	-16	-19	-23	-28	-32	-38	-44	-47	-51	-57	-62	-66	-69	-73
Percent change in numbers	3.2	0.0	-2.8	-8.4	-11	-17	-18	-22	-27	-31	-37	-43	-48	-54	-61	-64	-67	-72	-77	-80	-82	-85
Prince Edward Island																						
Percent change in weight	21.7	17.2	13.5	9.5	6.1	2.5	0.0	-1.7	-5.5	-9.4	-13	-16	-19	-21	-23	-25	-28	-30	-32	-34	-36	-39
Percent change in numbers	62.4	47.5	36.0	24.2	15.2	6.1	0.0	-3.8	-12	-20	-28	-33	-38	-42	-45	-48	-52	-55	-57	-59	-61	-65

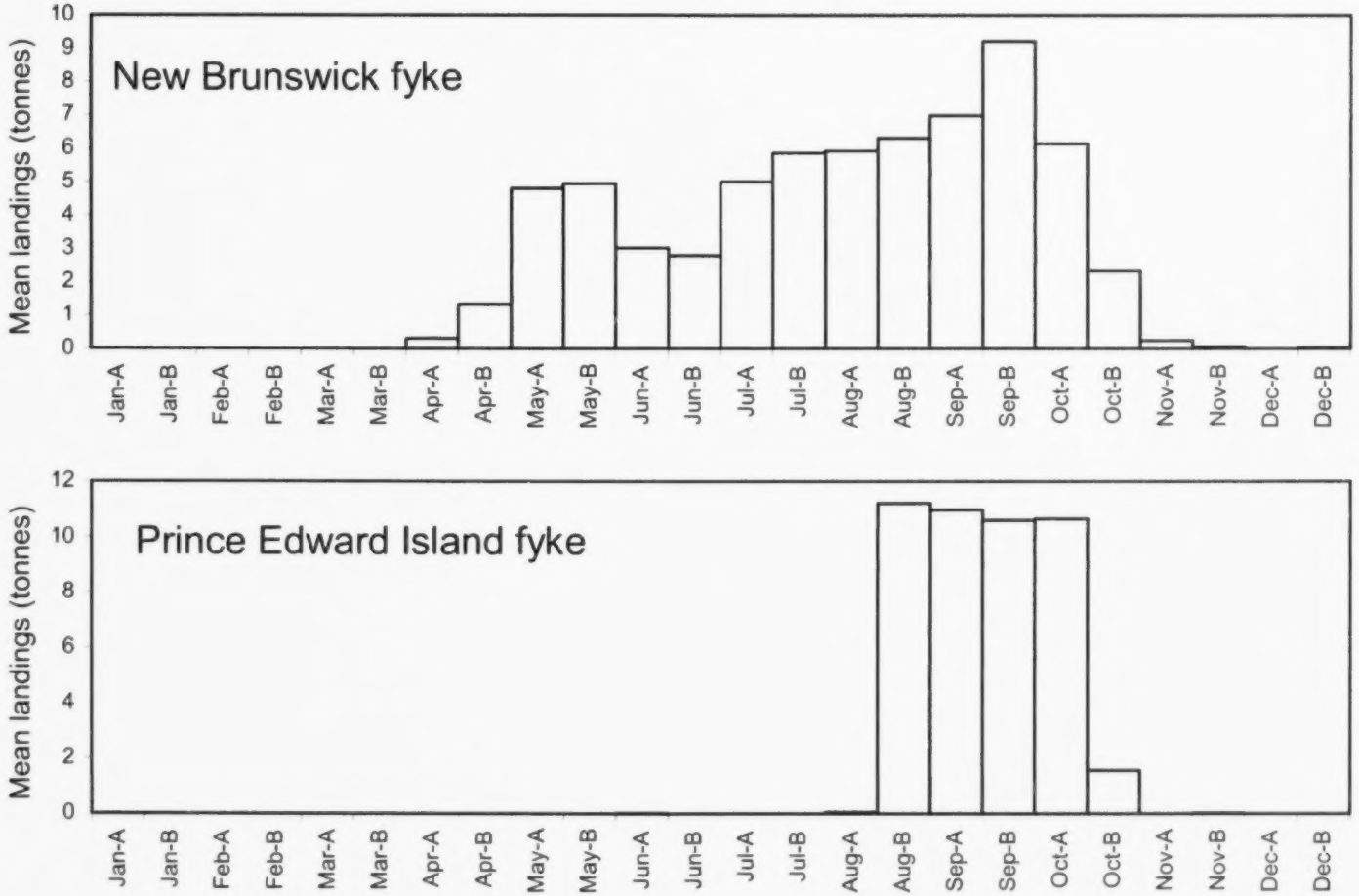

Fig. 1
Reported mean landings, 1998-2002, of American eels captured in fyke nets in Gulf New Brunswick and Prince Edward Island, by half-month.

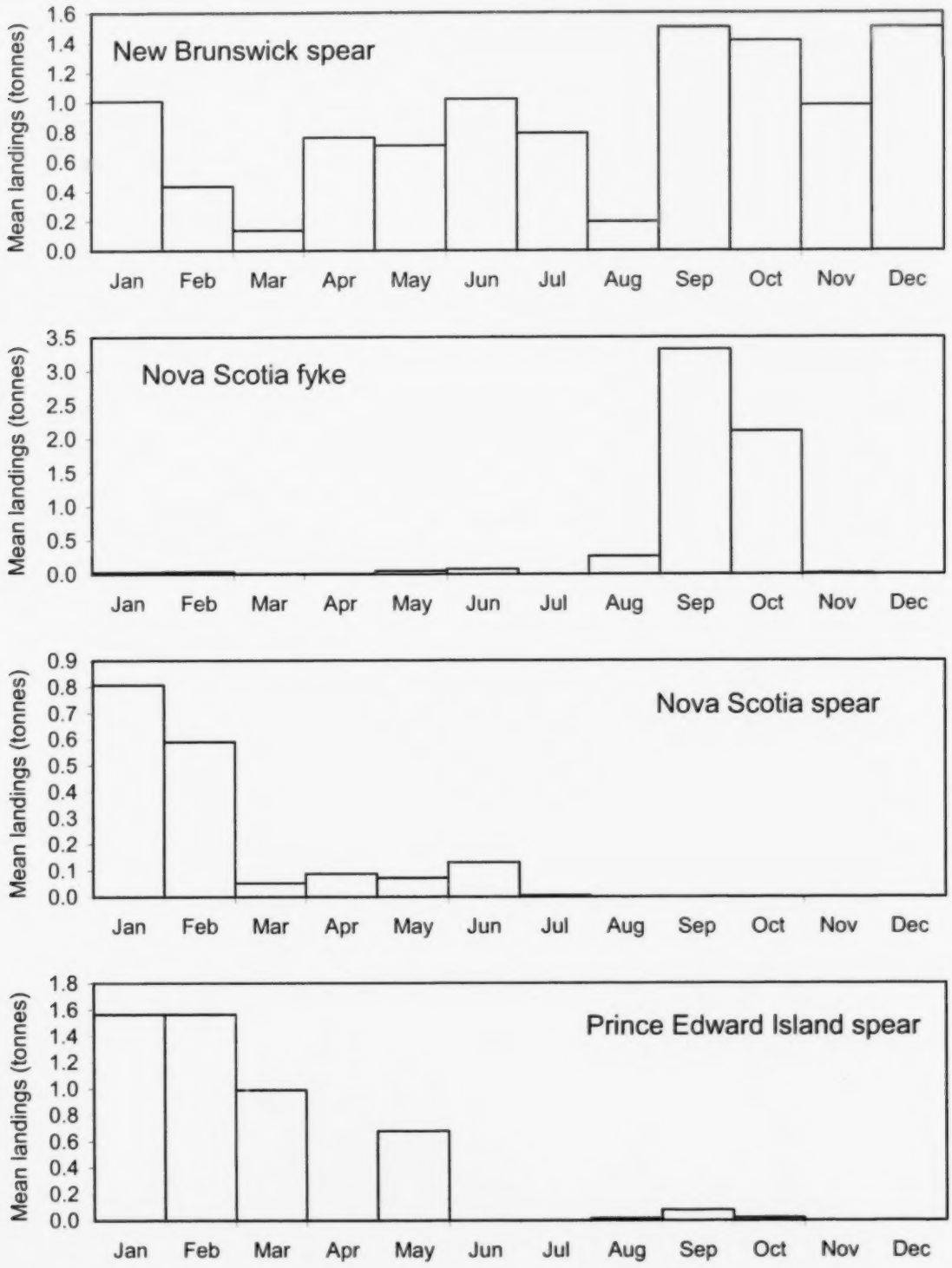

Fig. 2
Reported mean landings, 1998-2002, of American eels captured by spear in Gulf New Brunswick, Gulf Nova Scotia, and Prince Edward Island, and by fyke net in Gulf Nova Scotia, by month.

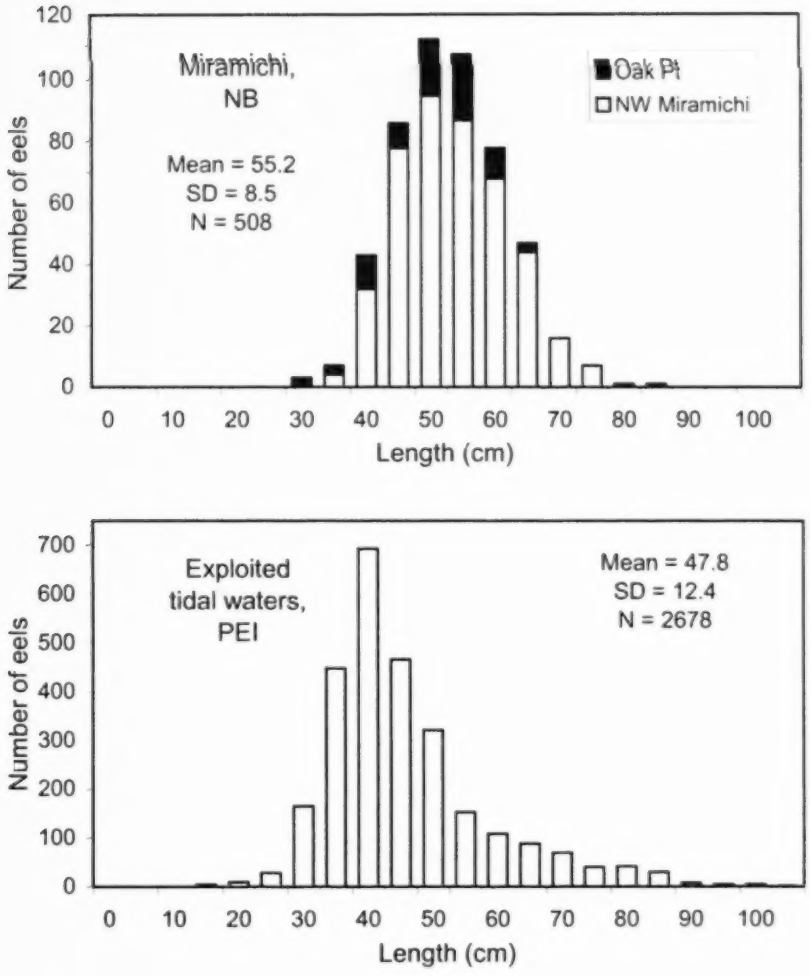

Fig. 3
Length frequencies of American eels captured in fyke nets in tidal waters in the southern Gulf of St. Lawrence. New Brunswick data are from Oak Pt., Miramichi Bay and South Esk, Northwest Miramichi River. Prince Edward Island data are from various locations on the north and east coasts of the province. Samples are from waters which are regularly exploited by commercial fisheries.